1.5 PHYSICS PLANS FOR THE 12-FT HYDROGEN BUBBLE CHAMBER*

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Introduction

The Argonne high energy physics laboratory has a 75-cm hydrogen bubble chamber operating as a facility. Later this year the 1-m MIT hydrogen chamber is expected to start taking physics pictures and will provide a second hydrogen chamber facility. The possible physics that can be done with these chambers depend on the beams they are provided with. Table I gives the details of the chambers and the beams. Since the ZGS can provide pions up to 12.4 GeV/c and the 12-ft chamber has many potential advantages over the smaller, conventional chambers for high energy work, it was decided to initially provide a high momentum beam for the chamber

Table I

Chamber Size	Magnetic Field	Beam
75-cm ϕ x 40-cm	32.5 kG	$\pi^{\pm}$ 0.5 to 7 GeV/c $K^{\pm}$ 2.5 to 5.5 GeV/c $\bar{p}$ 1.5 to 6 GeV/c
1-m ϕ x 50-cm	20 kG	π^{-} 0.5 to 5.5 GeV/c $K^{\pm}$ 1.5 to 2.5 GeV/c‡

The yields of high energy K mesons are sufficiently intense that, using an R.F. separated beam, kaons in the momentum range from 5 GeV/c to 9 or 10 GeV/c can be obtained with sufficient intensity for a bubble chamber exposure using reasonable proton intensities.

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‡The chamber is located at such a distance from the accelerator that such a beam could be built. The decision to build this beam has not been taken.

The location of the chamber relative to the accelerator is, therefore, set by the requirement of having sufficient distance to separate 10 GeV/c kaons. In addition to the bubble chamber, the authorization included a building to be used with external targets placed in a second extracted proton beam. This building will be located as shown in Fig. 1 and will mainly be used for other experiments than those connected with the 12-ft chamber. The extracted proton beam is along one edge of this building since space has been left for a future higher energy injector.

Neutrino Physics

The importance of studying neutrino interactions in hydrogen and deuterium is well known. The physics case has been well summarized by Professor Lagarrigue at this conference.

A schematic of a possible neutrino layout is given in Fig. 1. The extracted proton beam is transported down the proton building and focussed onto the target of the horn. This is a cylindrical current sheet, using capacitor discharge and focusses positive or negative secondary particles according to the direction of current flow. The focussed beam of mesons then decays, producing the neutrino beam. A thick steel shield absorbs the μ mesons. Figure 2 shows the main elements in the horn and decay tunnel geometry.

Neutrino Spectrum

If the angle-momentum spectra of pions and kaons are known, it is a straightforward matter to calculate the neutrino spectrum traversing a detector placed a certain distance from the target. This has been done using a Monte Carlo type calculation. Figure 3 shows the results of this calculation for the ZGS with full horn current (300 KA) and a comparison with the case of ideal focussing. Figure 4 shows the neutrino distributions perpendicular to the beam direction which this calculation predicts for various energy regions of the neutrino spectrum assuming a full horn current. The 12-ft chamber is seen to be fairly well matched to the size of the beam. The detector is 43.9 m from the horn with an 8.9-m thick iron shield in front of the bubble chamber detector (see Fig. 2 for layout).

Event Rates

We can estimate the actual event rates that can be obtained in the 12-ft bubble chamber by using our calculations of flux at the detector together with the theoretical elastic neutrino cross sections for a single pole axial vector form factor ($M_A = 0.8$). These results are shown in Fig. 5 as expected event rates per day. A horn current of 300 KA and a 60-cm beryllium horn target was assumed.

Additional assumptions used in these estimates are:

1. The fiducial volume of the bubble chamber contains 1.7-m tons of deuterium and is approximated by a rectangular volume 6-ft x 6-ft x 12-ft long. This amounts to about one half of the total visible volume.

2. The ZGS accelerates 2×10^{12} particles per pulse, which is the intensity today.

3. Repetition rate of the ZGS is 30 pulses per minute.

4. Extraction efficiency combined with horn target efficiency yields 10^{12} interacting protons per pulse.

This gives a total elastic event rate with a deuterium filling of the chamber of 50 elastic events per day or a total of about 150 events per day. Ideal focussing approximately doubles this rate and using an uranium absorber instead of iron will give a 30% increase.

LIST OF FIGURES

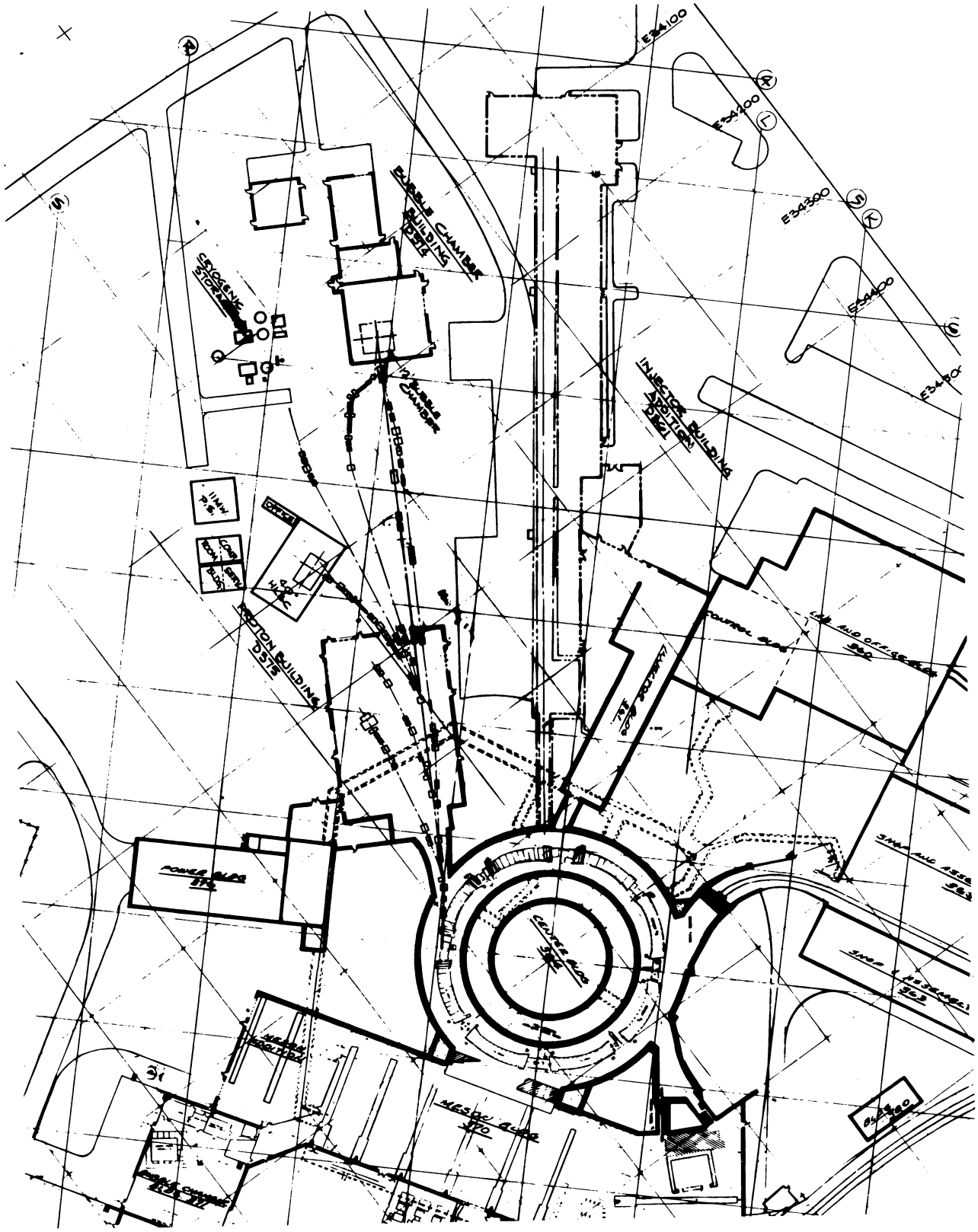

Fig. 1

Layout of Experimental Building
to be used with a Second Extracted Proton Beam

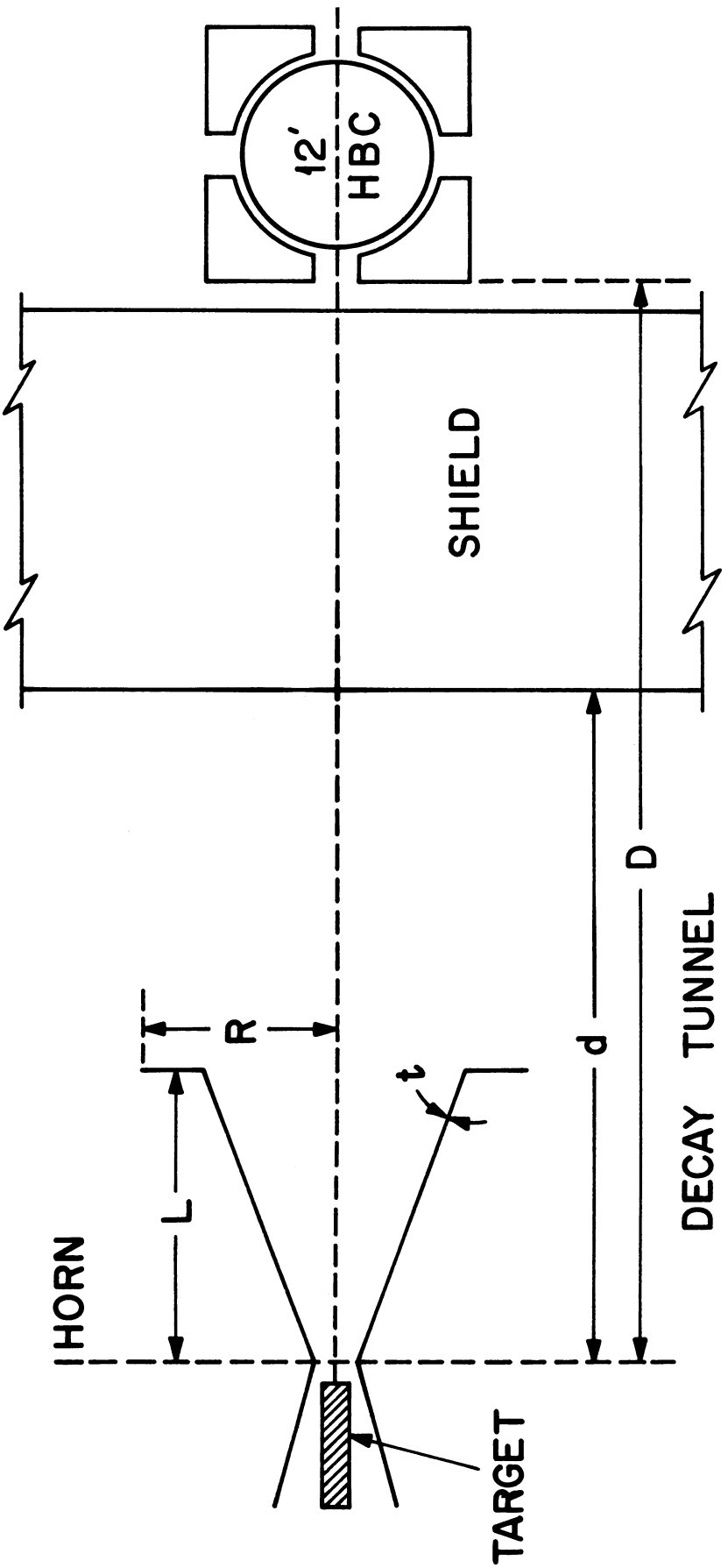

FIG. 2

HORN AND DECAY TUNNEL GEOMETRY

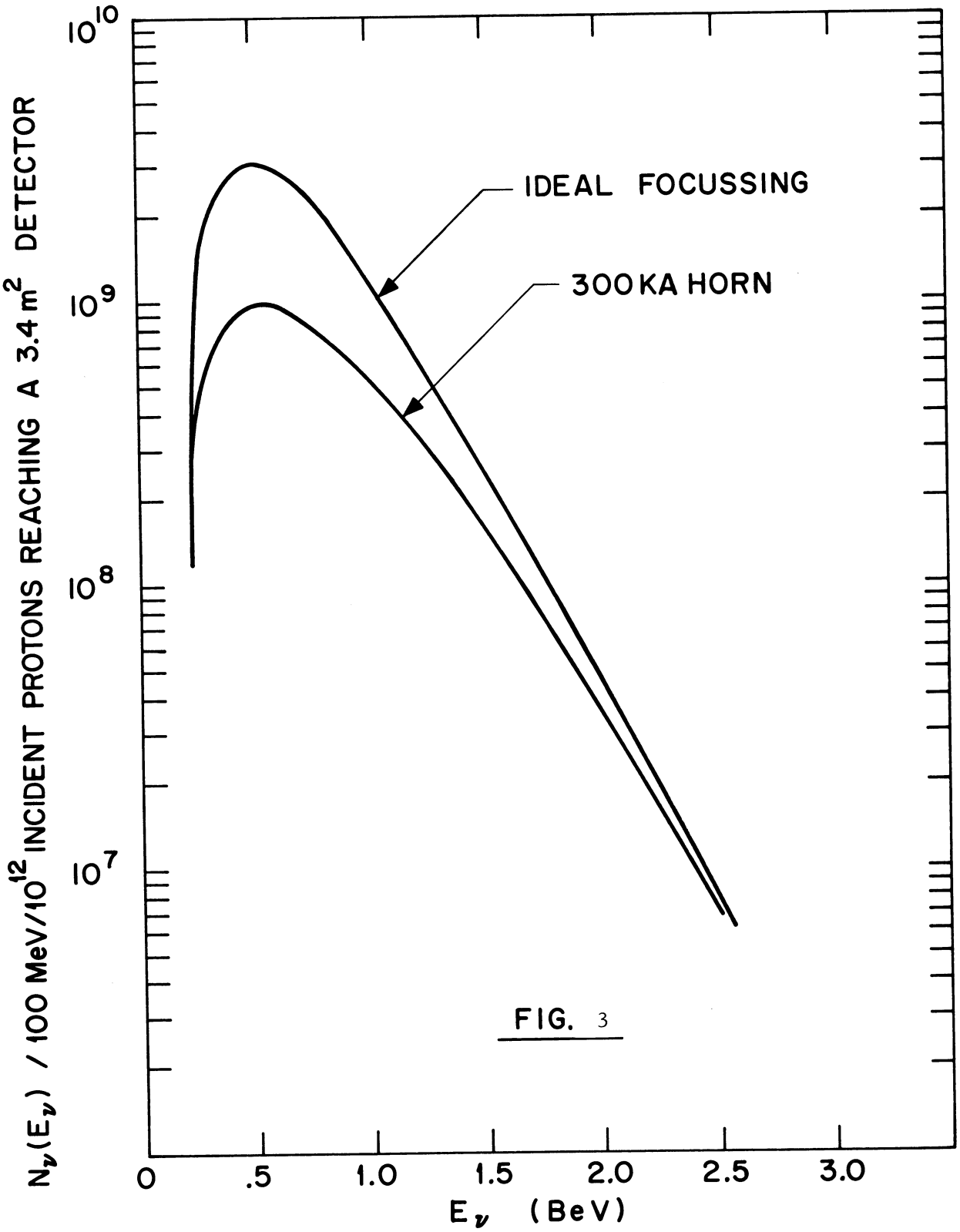
10^{10}
10^{9}
10^{8}
10^{7}
$N_\nu(E_\nu)$ / 100 MeV/10^{12} INCIDENT PROTONS REACHING A 3.4 m^2 DETECTOR
IDEAL FOCUSSING
300 KA HORN
0
.5
1.0
1.5
2.0
2.5
3.0
E_ν (BeV)

FIG. 3

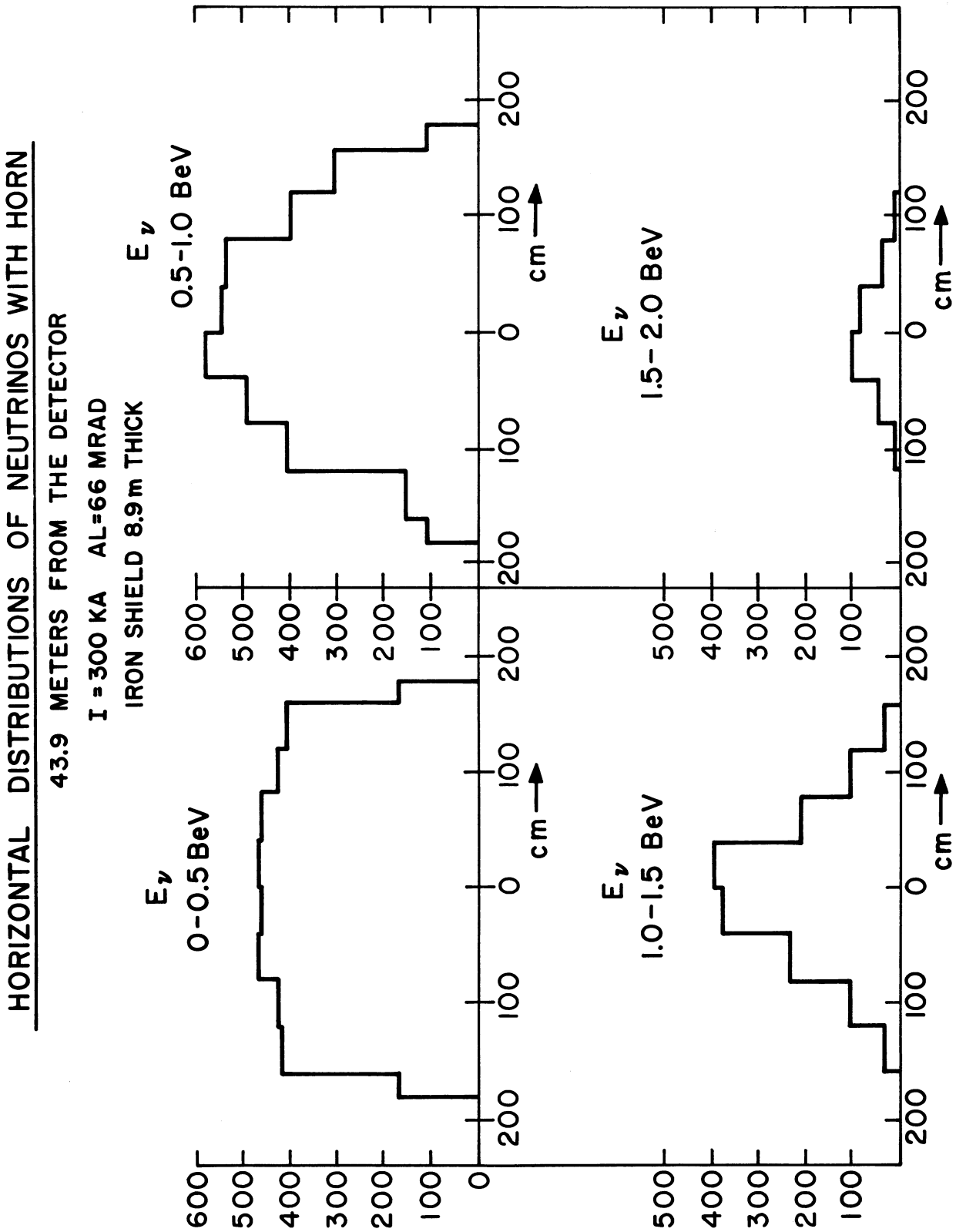
FIG. 4
HORIZONTAL DISTRIBUTIONS OF NEUTRINOS WITH HORN
43.9 METERS FROM THE DETECTOR
I = 300 KA AL=66 MRAD
IRON SHIELD 8.9 m THICK
E_ν 0-0.5 BeV
E_ν 0.5-1.0 BeV
E_ν 1.0-1.5 BeV
E_ν 1.5-2.0 BeV
cm
0
100
200
100
200
300
400
500
600

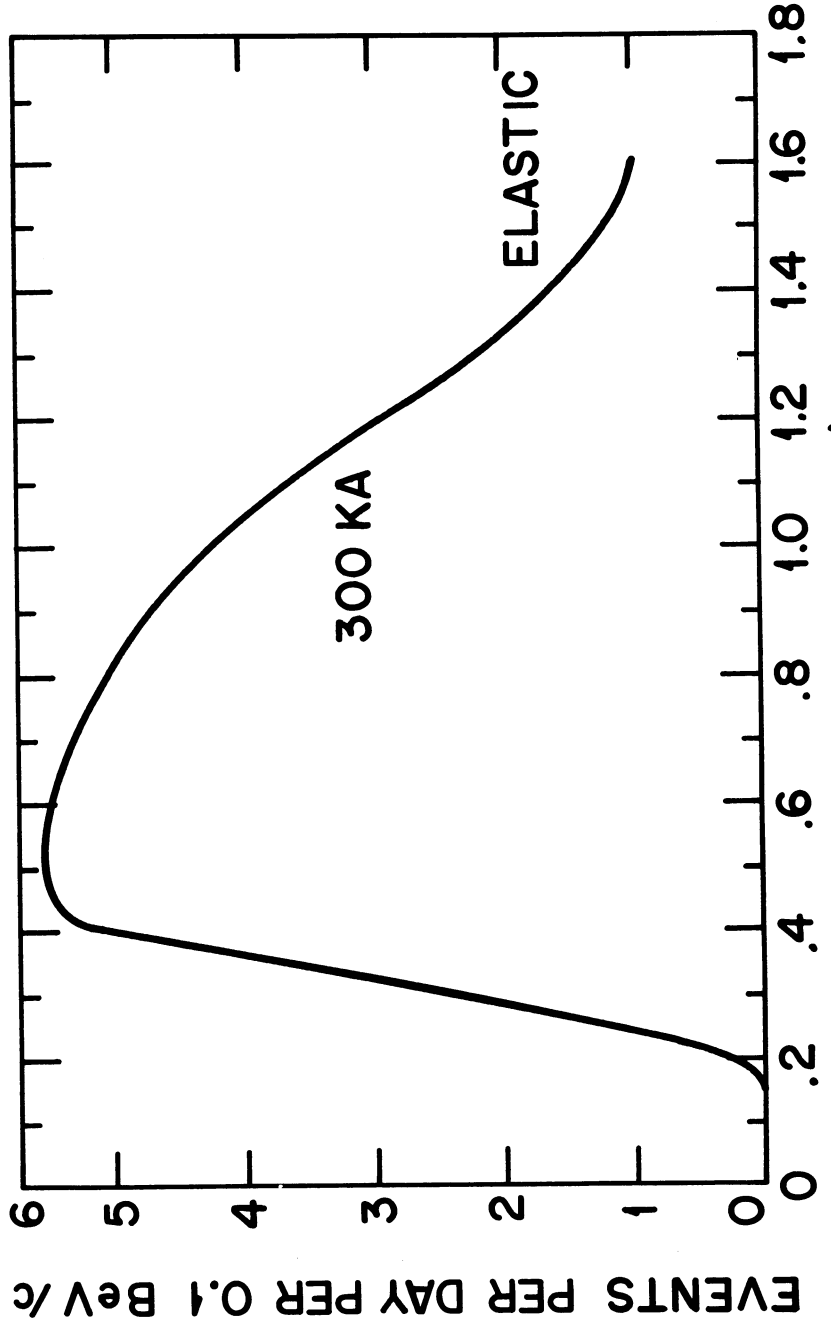

FIG. [5]

NEUTRINO EVENTS/DAY, 0.1 BeV/c FOR 300 KA HORN CURRENT, 1×10^{12} PROTON/2.0 sec., $M_A = 0.8$